Atmospheric Modeling Support For CREAMS II: Simulations of Mesoscale Atmospheric Circulation and Forcing in the Japan/East Sea

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LONG-TERM GOAL

To understand the physical processes of the air-sea interaction and coupling of the ocean and the atmosphere on the regional scale and to predict the variabilities of the coupled ocean- atmosphere systems.

OBJECTIVES

Our knowledge of the interactive processes of the ocean-atmosphere system of the JES is very limited, especially the effects of the atmospheric surface forcing associated with the winter-time Siberian cold-air outbreaks on ocean circulation and the oceanic feedback to the overlay atmosphere. During the past year we have focused on the simulations of the multiple cold-air outbreak storms and model validations with various satellite and in situ observations. The specific objectives are to provide high spatial and temporal resolution atmospheric surface forcing to ocean models and to support a pre-field-program planning for the U.S. JES and CREAMS II programs.

APPROACH

We use the Penn State University/National Center for Atmospheric Research atmospheric nonhydrostatic mesoscale model (MM5) to characterize the mesoscale structures of atmospheric synoptic forcing, especially for the winter-time Siberian cold-air outbreaks in the offings of Vladivostok and in the vicinity of the subpolar front and the summer-time tropical cyclone related disturbances near JES. Our general approach is to use multi-nested grids model to cover a large area in the outer domain and still resolve the fine mesoscale features in the inner domains. We use a triple-nests with 45, 15, and 5 km grid spacing for the outer and two inner domains, respectively. The outer domain covers a large portion of the Asian Continent and the northwest Pacific Ocean. The 15-km grid inner domain cover the JES region. The 5-km grid inner most domain is centered near Vladivostok, Russia where the strong, persistent valley winds were observed. The ECMWF global analysis fields and the NCEP global SST analysis are used to initialize MM5 and provide continuous lateral boundary conditions. The outer domain is run in a four-dimensional data assimilation (FDDA) mode to provide the best possible boundary conditions for the inner domains. The two inner nested domains are run in a forecast mode with no FDDA.

WORK COMPLETED

We have completed a 10-day long MM5 simulation of two extratropical cyclones associated with winter-time cold-air outbreak over the Japan/East Sea region during 1-10 January 1997. The model simulation has been validated with both the satellite and in situ observations including the Japanese Geosynchronous Meteorological Satellite (GMS-5) infrared cloud top temperature and water vapor images, the NASA Scatterometer (NSCAT) surface winds, and the surface measurements from the stations near the coastal regions and the JMA buoy at (39¡N, 138¡E).

RESULTS

The MM5 simulation captured the observed structure and the evolution of the two cold-air outbreak storms over the JES during 1-10 January 1997. The storm tracks matched closely with the satellite observed center locations of the storms from the IR and water vapor images. The model simulated surface wind gusts were up to 25 m s-1 which is very close to the observed 28 m s-1 at the JMA buoy during the first storm on 1 January 1997. The air-sea temperature difference reached 10-15¡C behind the surface cold front at 1200 UTC on 1 January 1997. These extreme conditions induced strong surface heat and momentum fluxes. The surface wind and rainfall patterns were greatly modulated by the complex coastal terrain surrounding the JES. The enhanced valley winds near Vladivostok were very persistent associated with both storms.

The MM5 simulated surface winds are also compared with the NSCAT swath and gridded data as well as the ECMWF global wind analysis. Our preliminary results indicate that 1) MM5 simulated surface winds are closer to the in-situ buoy measurements than NSCAT gridded data and the ECMWF global analysis in terms of both wind speed and directions, 2) the NSCAT swath winds (when available) are similar to MM5 and buoy winds, and 3) there are significant differences among the four NSCAT gridded products used in this study (Chen et al., 1998).

IMPACT/APPLICATIONS

This project has provided the first high spatial (15-km grid spacing) and temporal (hourly) surface forcing (heat and momentum fluxes) associated with the winter-time Siberian cold-air outbreaks in the JES. Recent ocean model (SOJ-POM) simulations using this MM5 surface forcing have show a great sensitivity in ocean response to the high-resolution atmospheric forcing which is very different from that climatological mean forcing and the ECMWF global analysis (Mooers et al., 1998). Cooperative atmospheric and ocean modeling work can provide some insights of the air-sea interaction and its potential impact on the deep ocean ventilation processes in JES.

TRANSITIONS

Our MM5 simulated surface forcing associated with the winter-time cold-air outbreak has been used to drive the SOJ-POM (Sea of Japan Ocean Model) by ONR PI (Dr. Chris MooersÕ ocean modeling group) at University of Miami. The MM5 simulations will be made available to other U.S. and international ocean modeling communities.

RELATED PROJECTS

This proposed study is a part of a joint atmospheric and oceanic modeling effort to support the U.S. JES and CREAMS II program. The MM5 simulated atmospheric mesoscale circulation has provide surface forcing for the regional ocean modeling effort funded by ONR at University of Miami (Dr. Mooers). The SOJ-POM SST will be used as a continuously varying lower boundary (hourly) forcing in MM5 simulations to test the sensitivity of the atmospheric circulations to the varying SST.

REFERENCES

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